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Performance Evaluation of Size, Book-to-Market and Momentum Portfolios

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Abstract

This article provides an extensive review on traditional and more sophisticated evaluation measures focusing on premium returns adjusted for the associated risk. The implementation of these performance measures on the HML, SMB, MOM, LT-Rev and ST-Rev empirical factors produces for first time a ranking of the aforementioned portfolios, revealing that the HML and MOM factor portfolios achieve the best and worst performance, respectively. This analysis goes one step further by implementing the same performance measures on portfolios formed by a specific characteristic, such as size, book-to-market or momentum, establishing thus a connection between these characteristics and portfolios' performance. Our empirical findings suggest that the traditional and downside performance measures lead to identical rankings, whereas drawdown-based ones influence the rank order among the portfolios of interest.

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Key Words: **Risk measures; Performance measures; Portfolio ranking; Fama/French factors.**

1. Introduction

In recent years, risk measurement is one of the topics of concern not only for financial institutions, due to the regulatory restrictions under the Basel II Capital Accord, but also for fund managers and the academic community. The ability of a performance measure to consistently compare different portfolios concerning

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their level of risk along with the fact that a performance measure should be easily understood and applied makes the choice of an appropriate measure rather important.

The construction of a performance measure demands an appropriate index that should quantify the associated risk. Apart from the traditional ones, such as the beta coefficient and the standard deviation, various specifications have been proposed to cover the evinced skewness and kurtosis of returns. Specifically, the introduction of downside risk indices, such as the Value-at-Risk, the Expected shortfall and the semi-standard deviation, through which only the left hand side of a return distribution is used to measure risk, has led to a plethora of risk-adjusted performance measures, adequate to rank investment portfolios. Moreover, a variety of new performance measures has also been developed accounting for different aspects of the incorporated risk, such as the economic performance measure of Goetzmann et al. (2007) and that of Homm and Pigorsch (2012) along with a variety of recently developed measures based on drawdown of portfolio returns.

Over the last decade, there has been a debate on the choice of the appropriate performance measure. Consistent with Phingsten et al. (2004), Eling and Schuhmacher (2005) and Eling (2008) suggested that different risk measures provide similar ranking results. Complementary to the analysis of Eling and Schuhmacher (2007), who investigated whether the choice of the risk measure affects the ranking performance of hedge funds by comparing 13 different risk measures, Auer and Schuhmacher (2013) also report similar findings about the rank order of different assets. Contrary to these analyses, Ornelas et al. (2012) and Zakamouline (2011) argued that the evaluation of investment funds is influenced by the measure employed. In particular, Zamakouline (2011) proved that the rank correlation between the Sharpe Ratio and other measures decreases for higher values of skewness.

In the present analysis, we compute an extensive set of performance measures, ranging from the traditional ones to more complicated. Contrary to earlier studies, this analysis focuses on the performance evaluation of empirical portfolios, the Fama/French, reversal and momentum factors, used by fund traders and other practitioners to forecast stock and bond market returns. Despite the forecasting ability of these portfolios, limited literature is available concerning their performance according to the associated risk, with the exception of Bakshi et al. (2011), who showed that changes in risk are negatively related to equity premium, value spread, size spread and momentum spread and proved that an increase in risk is connected with an underperformance of stock portfolios with high book-to-market, small capitalization and low momentum. The ranking results of the present analysis show that the MOM factor underperforms, while the HML and SMB factors evince as high-performance portfolios, an attitude which is maintained by employing either the traditional or the downside measures. However, when drawdown-based performance measures are applied, the performance results reveal some differences in the rank order of the competing portfolios.

Apart from ranking the aforementioned portfolios, this study contributes to the literature by establishing a link between (small and big) size, (low and high) book-to-market ratio (B/M) and prior-return of stocks and the exhibited performance of specific portfolios. Our ranking results suggest that small and high B/M portfolios appear as high-performance investments, while high momentum and low long-term and short-term reversal portfolios are connected with lower performance. This performance is evinced not only by the traditional performance measures, but also by the downside and the more sophisticated ones providing identical rankings, with minor exceptions.

The remainder of the paper is organized as follows. Section 2 illustrates the performance measures used to evaluate portfolios. Section 3 focuses on the data used and provides the ranking results. Finally, Section 4 summarizes the main results and concludes.

2. Performance measures for portfolio evaluation

2.1. Traditional performance measures

For decades, the performance of a portfolio was under evaluation through measures that quantified the embedded risk via the estimated standard deviation or the beta factor. Representative performance measures of this category are the Jensen (JR), the Treynor ratio (TR) and the Sharpe ratio (SR) (see Jensen, 1968, Treynor, 1965 and Sharpe, 1966), with the first two being calculated on the basis of the correlation between portfolio returns and market returns; namely, the beta factor β_i, and the last one employing the standard deviation, σ_i, of portfolio returns, as follows:

$$JR_i = E(R_i) - E(R_f) - \beta_i[E(R_M) - E(R_f)]$$

$$TR_i = [E(R_i) - E(R_f)] / \beta_i$$

$$SR_i = [E(R_i) - E(R_f)] / \sigma_i$$

where $E(R_i)$, $E(R_M)$ and $E(R_f)$ is the average portfolio, market and risk-free interest rate of return, respectively. Additionally, a modification of the SR, proposed by Treynor and Black (1973), is also included in the present analysis:

$$IR_i = [E(R_i) - E(R_f)] / \sigma_i^*$$

which employs the standard deviation of excess returns.

2.2. Downside performance measures

Downside risk indices, such as semi-standard deviation or lower partial moments (LPM) of order 1 and 3, Value-at-Risk along with its Cornish-Fisher expansion and expected shortfall, have rapidly gained acceptance among both academics and practitioners due to the fact that they include only negative deviations, incorporating thus movements associated exclusively with losses.

Based on these risk indices, a variety of performance ratios have been introduced, among of which are the Sortino Ratio, introduced by Sortino and Price (1994), which incorporates the semi-standard deviation of portfolio i of returns, $sd_i = E(\max(E(R_i) - R_i, 0))$, the Shadwick and Keating (2002) Omega Ratio and the Kaplan and Knowles (2004) Kappa3 Ratio, that incorporate LPM of order 1 and 3 for the full sample of returns (N represents the total number of observations), respectively, given by:

$$LPM_{ni} = (1/N)\sum_{i=1}^{N} \max(E(R_i) - R_i, 0)^n$$

The concerning downside performance measures are given, as follows:

$$Sortino_i = [E(R_i) - E(R_f)] / sd_i$$

$$Omega_i = 1 + [E(R_i) - E(R_f)] / LPM_{1i}$$

$$Kappa3_i = [E(R_i) - E(R_f)] / \sqrt[3]{LPM_{3i}}$$

Additionally, this analysis employs the generalized Sharpe Ratio, G_SR, proposed by Dowd (2000), the Gregoriou and Gueyie (2003) modified Sharpe Ratio, M_SR, and the Conditional Sharpe Ratio, C_SR, proposed by Agarwal and Naik (2004):

$$G\_SR_i = [E(R_i) - E(R_f)] / VaR_i$$

$$M\_SR_i = [E(R_i) - E(R_f)] / MVaR_i$$

$$C\_SR_i = [E(R_i) - E(R_f)] / ES_i$$

With respect to the employed indices VaR_i and ES_i, we estimate them under the assumption of normal distributed series of returns, as: $VaR_i = z_a \times \sigma_i$ and $ES_i = \left(\sigma_i / (1-a)\sqrt{2\pi}\right) e^{-z_a^2/2}$, while the $MVaR_i$ risk index for non-normal returns as: $MVaR_i = \sigma_i (z_a + (z_a^2 - 1)S_i / 6 + (z_a^3 - 3z_a)E_i / 24 - (2z_a^3 - 5z_a)S_i^2 / 36)$, where $z_a = 2.33$ is the $\alpha = 99\%$-quantile of the standard normal distribution, S_i is the skewness and $E_i = k_i - 3$ the excess kurtosis of the series of returns.

2.3. New approaches for performance measures

Two more performance measures are employed, the one proposed by Goetzmann et al. (2007), which is the portfolio's premium return after adjusting for risk for an investor with a relative risk aversion of 2 ($\gamma = 2$), known as manipulation-proof performance measure (MPPM) and the economic performance measure (EPM) proposed by Homme and Pigorsch (2012b), which is a generalized form of the Sharpe Ratio, with respect to the non-normal distributions, that incorporates the Aumann and Serrano (2008) index, AS_R ($AS_{R_i - R_f}$), to quantify the risk of the R_i (or the excess $R_i - R_f$) series of returns, respectively:

$$MPPM_i = \left(\frac{1}{1-\gamma}\right) \ln\left[\frac{1}{N}\sum_{t=1}^{N}\left(\frac{1+R_i}{1+R_f}\right)^{1-\gamma}\right]$$

$$EPM_i = E(R_i) / AS_{R_i} = [E(R_i) - E(R_f)] / AS_{R_i - R_f}$$

where the risk index is the positive number that satisfies the following equation: $E[\exp(-R_i / AS_{R_i})] = 1$. For normal distributions, the EPM converges to two times the squared Sharpe Ratio, inducing thus the same ranking asymptotically, while for series with low (high) skewness and/or relatively high (low) excess kurtosis, the portfolio is ranked lower (higher) by the EPM than by the Sharpe Ratio.

2.4. Drawdown-based performance measures

Finally, performance measures based on drawdown quantities are rather popular, especially among commodity traders, due to the incorporated information about continuously accumulated losses. Following the methodology of Auer and Schuhmacher (2013), the employed performance measures are calculated on the basis of monthly excess returns. That is, the Calmar Ratio, which quantifies risk through the largest negative cumulated uncompounded excess returns, $mdd_i = \max_{ij>i}(-z_{ij})$, two ratios that use the K largest losses, $cdd_{i,k}$; namely, the Sterling and Burke Ratio, and two more ratios that measure each portfolio' risk by assigning weights to drawdowns (only if there exist) from the previous peak, $ddp_{i,t} = \max_{1\le i\le t}(-z_{i,t})$; namely, the Pain Ratio along with the Martin Ratio. The aforementioned measures are given as:

$$Calmar\_Ratio_i = [E(R_i) - E(R_f)] / mdd_i$$

$$Sterling\_Ratio_i = [E(R_i) - E(R_f)] / \left[(1/K) \sum_{k=1}^{K} cdd_{i,k} \right]$$

$$Burke\_Ratio_i = [E(R_i) - E(R_f)] / \sqrt{\sum_{k=1}^{K} (cdd_{i,k})^2}$$

$$Pain\_Ratio_i = [E(R_i) - E(R_f)] / \left[(1/N) \sum_{t=1}^{N} ddp_{i,t} \right]$$

$$Martin\_Ratio_i = [E(R_i) - E(R_f)] / \sqrt{\frac{1}{N} \sum_{t=1}^{N} (ddp_{i,t})^2}$$

Note that for the calculation of the Sterling and Burke ratios we set $K = 5$, following the existing literature (Eling (2008), Eling and Schuhmacher (2007) and Auer and Schuhmacher (2013)).

3. Empirical results on portfolio ranking

3.1. Data

The data used in the following analysis are monthly returns for the period from January 2000 to December 2013 (168 observations) on the market portfolio (CRSP value-weighted portfolio return), the risk-free interest rate of return (1-month T-bill returns from Ibbotson and Associates, Inc.), the HML and SMB factors, the momentum (MOM), Long-Term Reversal (LT) and Short-Term Reversal (ST) portfolios. Additionally, the dataset is enriched with the smallest (size1) and the biggest (size10) portfolios among 10 portfolios formed by size, the lowest (BM1) and highest (BM10) one among the 10 decile portfolios formed based on their book-to-market ratio, along with the lowest and highest ones among the 10 prior-return-based portfolios, which are constructed using NYSE prior (2-12), (13-60) and (1-1) returns, referred as mom1, mom10, LT1, LT10, ST1 and ST10, respectively. The full dataset along with details about the construction of each portfolio of returns is available at Kenneth French's website (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library. html).

3.2. Ranking the Fama/French portfolios

The present empirical analysis aims to evaluate the performance of the popular HML, SMB, MOM, LT and ST portfolios with respect to their risk-adjusted return using the most widely used performance measures. According to the performance realizations produced by the different measures, reported in Table 1, portfolios constructed according to their previous performance are ranked low. Specifically, according to our ranking results produced by the Sharpe Ratio, the MOM factor underperforms (suggesting the relative low adjusted-for-risk performance of the 'winners' over the 'losers') followed by the ST, LT, SMB and finally the HML, which achieves the best performance. As for the market portfolio of returns, the empirical results show that it should be characterized as a medium-performance portfolio, lying between the LT-Rev and the SMB factor.

Similar rankings pertain when the employed portfolios are evaluated on the basis of the alternative measures. In particular, with the exception of the Treynor ratio, the Jensen and the Omega, the remaining traditional and downside performance measures along with the MPPM measure all provide identical rank order for the portfolios assumed. As observed, even after penalizing excess kurtosis (or negative skewness) by applying the EPM performance measure, the rank order is maintained and both measures leading to identical rankings.

Table 1. Performance measures on the FF, reversal and momentum portfolios.

Measures	**Market**	**HML**	**SMB**	**MOM**	**LT_Rev**	**ST_Rev**
Treynor ratio	0.0029	*-0.0441*	0.0113	-0.0003	**0.0118**	0.0041
Jensen	*0.0000*	**0.0036**	0.0019	0.0015	0.0007	0.0004
Sharpe ratio	0.0617	**0.0991**	0.0727	*0.0021*	0.0357	0.0310
Inform. ratio	0.0613	**0.0998**	0.0725	*0.0021*	0.0357	0.0310
Sortino ratio	0.0806	**0.1426**	0.1117	*0.0027*	0.0528	0.0460
G-SR 99%	0.0265	**0.0425**	0.0312	*0.0009*	0.0153	0.0133
M-SR 99%	**0.0322**	0.0308	0.0141	*0.0009*	0.0127	0.0095
C-SR 99%	0.0233	**0.0375**	0.0275	*0.0008*	0.0135	0.0117
Omega	1.1587	**1.2911**	1.2175	*1.0067*	1.0922	1.0945
Kappa3	0.0590	**0.0966**	0.0731	*0.0016*	0.0406	0.0317
MPPM (γ=2)	0.0006	**0.0022**	0.0014	*-0.0039*	0.0002	-0.0005
EPM	0.0116	**0.0290**	0.0181	*0.0001*	0.0071	0.0044
exc_EPM	0.0074	**0.0198**	0.0109	*0.0000*	0.0026	0.0019
Calmar ratio	0.0045	0.0253	**0.0405**	*0.0005*	0.0156	0.0063
Sterling ratio	0.0048	0.0555	**0.0627**	*0.0006*	0.0185	0.0102
Burke ratio	0.0022	**0.0219**	0.0257	*0.0003*	0.0082	0.0043
Pain ratio	0.0142	**0.0314**	0.0253	*0.0004*	0.0047	0.0094
Martin ratio	0.0108	**0.0234**	0.0195	*0.0003*	0.0039	0.0070

Notes: Bold and Italics indicate the best and the worst performance, respectively.

Concerning the ranking deviations, the Treynor Ratio leads to a completely different rank order, while the Jensen measure affects only low-performance portfolios. With respect to the Omega measure, it provokes differences in rank order for low-performance portfolios; namely, the LT and ST reversal ones, mainly caused

by the smaller extent to which the negative deviations from the mean return are weighed, compared to higher-order ratios, Kappa3 and Sortino.

Turning to the drawdown-based measures, our findings point to different rankings. In particular, for the high-performance HML and SMB portfolios, the Calmar, Sterling and Burke ratios produce different rank order, while the results of the Pain and Martin ratios indicate differences in rankings only when attention is restricted to the low-performance LT-Rev and ST-Rev portfolios.

Despite the fact that the majority of the employed measures produce identical rankings, some of them face disadvantages that make them inappropriate for portfolio evaluation under certain conditions. Specifically, during periods of extraordinary high returns, the popular Sharpe ratio would appear lower than drawdown measures by incorporating both-side deviations of returns. From a practical point of view, though, the choice of performance measure does not have a crucial influence on the relative evaluation of portfolio of returns, with a few exceptions.

3.3. Ranking portfolios based on size, book-to-market and previous performance

In order to examine how specific stock characteristics, such as the size, book-to-market ratio or prior

Table 2. Performance measures on the size and book-to-market portfolios.

Measures	size1	size10	BM1	BM10
Treynor ratio	0.0022	0.0015	*0.0014*	**0.0064**
Jensen	-0.0007	-0.0013	*-0.0015*	**0.0044**
Sharpe ratio	0.0460	0.0308	*0.0278*	**0.1128**
Inform. ratio	0.0457	0.0306	*0.0276*	**0.1126**
Sortino ratio	0.0608	0.0410	*0.0368*	**0.1552**
G-SR 99%	0.0197	0.0132	*0.0119*	**0.0484**
M-SR 99%	0.0229	0.0151	*0.0139*	**0.0338**
C-SR 99%	0.0174	0.0117	*0.0105*	**0.0427**
Omega	1.1204	1.0810	*1.0731*	**1.3136**
Kappa3	0.0443	0.0301	*0.0267*	**0.1095**
MPPM (γ=2)	0.0000	-0.0006	*-0.0012*	**0.0029**
EPM	0.0075	0.0041	*0.0034*	**0.0302**
exc_EPM	0.0410	*0.0274*	0.0276	**0.1615**
Calmar ratio	0.0029	0.0017	*0.0015*	**0.0235**
Sterling ratio	0.0032	0.0019	*0.0016*	**0.0260**
Burke ratio	0.0014	0.0009	*0.0007*	**0.0116**
Pain ratio	0.0081	0.0043	*0.0032*	**0.0569**
Martin ratio	0.0066	0.0037	*0.0028*	**0.0339**

Notes: Bold and Italics indicate the best and the worst performance, respectively.

returns, are related to portfolio performance, ten (10) different empirical portfolios of returns are employed; each one characterized by either small or big size, low or high book-to-market and low or high momentum/ reversal.

Our findings in Table 2 suggest that value-stock portfolios (high B/M) perform better closely followed by low-market-capitalization portfolios. On the other hand, growth-stock portfolios (low B/M) and big-size ones achieve low performance. More importantly, identical rankings are induced by all the employed performance measures (with a few exceptions).

Turning to the performance of portfolios characterized by low/high momentum, long-term and short-term reversal, Table 3 provides the ranking results based on the performance measures. The results indicate almost identical rankings, with the portfolio of low momentum underperforming compared to that of high momentum, while the opposite takes place for the portfolios characterized by low long-term reversal and low short-term reversal. Deviation in the rank order is created only by the exc_EPM measure and for the ranking of the competing momentum portfolios. Overall, low long-term reversal and high short-term reversal are the best and worst performing portfolios, respectively.

Table 3. Performance measures on the high and low momentum/reversal portfolios.

Measures	**mom1**	**mom10**	**LT1**	**LT10**	**ST1**	**ST10**
Treynor ratio	0.0008	0.0046	**0.0073**	0.0027	0.0014	*0.0000*
Jensen	*-0.0040*	0.0018	**0.0060**	-0.0002	-0.0024	-0.0032
Sharpe ratio	0.0142	0.0764	**0.1318**	0.0532	0.0271	*-0.0007*
Inform. ratio	0.0142	0.0761	**0.1315**	0.0530	0.0270	*-0.0007*
Sortino ratio	0.0215	0.1016	**0.1848**	0.0698	0.0362	*-0.0009*
G-SR 99%	0.0061	0.0328	**0.0566**	0.0228	0.0116	*-0.0003*
M-SR 99%	0.0042	0.0331	**0.0565**	0.0278	0.0114	*-0.0003*
C-SR 99%	0.0054	0.0289	**0.0499**	0.0201	0.0102	*-0.0003*
Omega	1.0415	1.2016	**1.3437**	1.1389	1.0777	*0.9982*
Kappa3	0.0160	0.0730	**0.1388**	0.0499	0.0253	*-0.0007*
MPPM (γ=2)	*-0.0100*	0.0006	**0.0042**	-0.0006	-0.0062	-0.0038
EPM	0.0008	0.0152	**0.0405**	0.0083	0.0024	*0.0000*
exc_EPM	0.0311	0.0114	**0.0346**	0.0055	0.0014	*0.0000*
Calmar ratio	0.0009	0.0101	**0.0829**	0.0041	0.0021	*0.0000*
Sterling ratio	0.0011	0.0106	**0.1521**	0.0042	0.0026	*0.0000*
Burke ratio	0.0005	0.0048	**0.0756**	0.0019	0.0011	*0.0000*
Pain ratio	0.0040	0.0199	**0.0810**	0.0108	0.0072	*-0.0001*
Martin ratio	0.0029	0.0149	**0.0509**	0.0082	0.0054	*-0.0001*

Notes: Bold and Italics indicate the best and the worst performance, respectively.

4. Conclusion

This study provides an extensive review of the most widely used performance measures for the evaluation of portfolio of returns. An important contribution of this paper is that it reveals the rank order of the popular

Fama/French, reversal and momentum portfolios, which are factors mainly used by fund traders as they exhibit significant forecasting ability on stock and bond returns. The results suggest that, among the employed factors, the MOM factor appears as a low-performance portfolio, while the SMB and HML factors perform the best. This performance is evident not only by the traditional performance measures, such as the Sharpe Ratio or the Information ratio, but also by measures based on downside risk indices. On the other hand, measures based on drawdowns lead to different rank order for middle- and high-performance portfolios, meaning that for purposes of avoiding the worst investment opportunity, the choice of the measure does not affect ranking.

In order to identify how size and book-to-market ratio are related to performance, different portfolios with these specific characteristics are evaluated. Our findings suggest that portfolios constructed by small-size stocks and portfolios of high book-to-market stocks perform better than portfolios of the opposite characteristics. This evidence is provided by almost all the measures employed, signalling that the choice of the performance measure does not change the ranking result. Additionally, this study contributes to the literature by presenting how performance is related with portfolios constructed based on prior performance, momentum or reversal. Our ranking results reveal that portfolios of high momentum or low long-term and short-term reversal exhibit high performance. This attitude is evident independently of the measure applied, revealing once again that the impact of using different measures is insignificant, and thus, from an empirical perspective, any of the employed performance measures could be used. However, identical rankings may lead to important economic significance for investors and managers, which is an issue that reserves further research.

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